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Extended Summaries SCI Pesticides Group Symposium Pest Management in Turf

The following are extended summaries based on papers presented at the Symposium 'Pest Management in Turf', organised by J. M. Smith, L. G. Copping and P. J. Ryan on behalf of the SCI Pesticides Group and held at the Hotel Metropole, Brighton, UK on 20 November, 1995. They are entirely the responsibility of the authors and do not necessarily reflect the views of the Editorial Board of Pesticide Science.

Biological Control of Insect Pests in Turfgrass

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Insect pests are a serious problem in turfgrass management. Some species can be easily controlled with available chemical control agents; many, however, live underground and are difficult to control because chemicals do not reach their target and are broken down by the microbial fauna in the thatch layer. Increasing pressure is put on turfgrass managers to reduce the use of chemical pesticides. New golf courses in some countries in Western Europe are permitted only if they restrict or completely omit the use of chemical pesticides. Turfgrass is used for sports and recreation and this conflicts with the use of chemical pesticides that have safety periods. In the Netherlands, for instance, sports fields are not allowed to be used for a period of five days after the use of parathion to control leatherjackets (*Tipula paludosa* Mëigen).

Use of selective biological control agents may overcome some of these problems. The environmental impact is lower and a safety period after use is not usually required. Some biological control agents, such as entomopathogenic nematodes, actively search for their hosts hiding in the soil and others, such as viruses, are highly infectious, spread easily and cause epizootics. Biocontrol agents can also provide long-term reduction of insect populations.

Turfgrass is a suitable niche market for biological control agents. They are often more expensive, slower acting and less effective than chemical pesticides, but on turfgrass these drawbacks can be compensated by their benefits. Long-term reduction of pest damage, low input of chemicals and reduction of labour input can be important factors. Therefore, some biologicals are already in use in turfgrass management and other products are likely to be used in the near future. This summary reviews the present state of biological control on turfgrass and discusses the possibilities for further development of biological control agents for management of turfgrass insect pests.

Scarabaeid grubs are a major pest in turfgrass worldwide, in particular on golf courses. In Europe the main species are *Phyllopertha horticola* (L.) and *Amphimallon solstitialis* (L.). In North America, *Popillia japonica* Newman, *Rhizotrogus majalis* Razoumowsky, *Anomala orientalis* Waterhouse and *Cyclocephala* spp. cause problems. In Japan and Asia similar problems are caused by *P. japonica* and *Anomala* species. Options for biological control of grubs[1] are the use of fungi, *Bacillus popillia* Dutky or baculoviruses but they have their limitations for practical use and are not used on a wide scale at the moment. Nematodes have qualities that make them suitable to become a major factor in the control of grubs. They are capable of killing many different species of grubs, they actively disperse through soil, they seek out their hosts and they can be mass produced and commercialized. However, the defence mechanisms of the grubs and the limited persistence and activity of entomopathogenic nematodes, are still major obstacles to a wider use of nematodes for grub control. The 'Bui Bui'-strain of *Bacillus thuringiensis* Berliner (Bt) is a control agent that is new on the market in the USA. The first results against Japanese beetle larvae seem to be promising.

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Leatherjackets, larvae of craneflies (*Tipula* spp.), cause serious damage in grass in NW Europe and the west coast of North America. *B. thuringiensis israelensis* Goldberg & Margalit (Bti) has been effectively used to control tipulid larvae. The method will probably come into practice within the next few years.[2]

Caterpillars such as sod webworms and cutworms can be controlled effectively by application of entomopathogenic nematodes that are already on the market in the USA as commercial products for use on turf.[3]

Mole crickets are a problem in turf in the South-East of the USA. Parkman and Smart used single inoculative applications of the entomopathogenic nematode *Steinernema scapterisci* Nguyen & Smart on golf courses in Florida with very positive results.[4]

Curculionid larvae such a bill bugs are very sensitive to entomopathogenic nematodes. Control with nematode products on the market seems effective and reliable and can be combined with the control of caterpillars.[3]

Turf management options. Occurrence and abundance of natural enemies of turf pests can be stimulated by management of turf and its surroundings. Umbelliferous plants such as wild carrot (*Daucus carota* L.) and hogweed (*Heracleum sphondylum* L.), for instance, are highly attractive for grub parasitoids such as *Tiphia* species. Egg production by female parasitoids is stimulated by their feeding on pollen. Providing room for these 'weeds' on a golf course can be important to keep grub populations within limits.

Resistant grass varieties can be used to reduce the development of certain insect pests. Grass varieties with *Acremonium* endophytes, for instance, are known to reduce the feeding and development of grubs and probably other insects as well.

Conclusions Biological control is an option for most insect pests in turfgrass. Scarabaeid grubs remain difficult to control, but both entomopathogenic nematodes and Bt Bui Bui are likely to become useful in practice. Caterpillars, curculionid larvae and mole crickets can already be controlled by entomopathogenic nematodes. For leatherjacket control, Bti will become available. Other problems in turf maintenance such as weeds, diseases, earthworms, moles and rodents cannot be solved with biological control agents. Management options are sometimes available to minimize their occurrence and problems.[3] Biological management of turfgrass seems feasible at this moment only if one is willing to occasionally tolerate some damage and some weeds. Integrated turfgrass management, with clever use of management options to minimize risks, with biological control whenever possible, and the use of chemical pesticides in case things get out of hand can be practised on most turfgrass already.

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Practical Aspects of Pesticide Application in Amenity Turf

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This company has specialised in the contract application of pesticides in the amenity and industrial weed control markets for the past 23 years. During that time, although it might be expected that matters have changed quite dramatically, and that some groundbreaking new technology has evolved, unfortunately, very little has changed.

Much of our work involves the control of weeds on an annual basis for local authorities, public utilities, government departments, industry and a wide range of other people with amenity or industrial land to manage, that is anywhere that weeds grow in a non-agricultural situation. The work is usually carried out through competitive tender, so that it is necessary to find the most economic and efficient method of applying the products we use, and to make sure that all current legislation is adhered to, with health and safety to the operator and the public very much in the forefront.

Some twelve years ago, controlled droplet application (CDA) gained a new surge of interest in the amenity market. A new lightweight applicator was developed to apply products that were pre-mixed and packaged ready for use; uniform droplets were distributed by a spinning disc with the claim that as the droplets were of

optimum size they did not present a drift problem. In practice, many operators found that this was not the case and preferred to carry on using the knapsack sprayer. On larger areas, such as sports fields, golf courses and airfields, it was necessary to use conventional booms mounted on a Land Rover or similar four-wheel-drive vehicle.

This company has recognised that safe application methods are as vital to the industry as the most efficient and effective practices. There is a belief that more legislation will be forthcoming that will require application to the target only; that is, spray drift will have to be controlled or contained. For this reason we have expanded much time and many resources investigating new ideas for the design of sprayers to be used in amenity situations. We considered that there is an unacceptable problem of spray drift when spraying in amenity grassed areas with a conventional suspended spray boom. Most booms are suspended at *c* 0·5 m from the ground; if they were any lower, the boom might hit the ground when working on uneven land. However, booms suspended at this height while spraying close-mown grass will obviously be very vulnerable to gusts of wind and, even on a reasonable spraying day, some light drifting can be seen by bystanders. This not only causes an environmental problem, but also alarm and concern to the public in the vicinity.

In order to re-design a sprayer specifically for treating amenity turfgrass areas we produced a specification and commissioned the Silsoe College of Engineering to carry out research using computer-simulated studies and a wind tunnel. These studies indicated benefits when using a perforated hood which allowed throughput of air but baffled stronger wind forces. They also indicated that a semi-circular hood design was the best shape for a shroud and that angling the spray bar forward by 60 degrees reduced wind drift. Prototypes for field testing are now being produced in conjunction with a major manufacturer.

Another application technique that has come to our attention is root-zone injection which was developed principally for the aeration of fine turf such as that on bowling and golf greens, etc. In this, a very high pressure water jet is pulsed into the ground and the ballistic action of the water can create a cavity 8–10 in deep without disturbing the surface. This allows greens to be injected in minimum time without disturbing play. Some machines have been designed to incorporate a wide range of products that can be injected into the ground; in particular, polymers, wetting agents, liquid fertilisers, fungicides etc. can all be placed within the root zone which is often the most effective situation. This represents a new and interesting development in the placement of pesticides and one that warrants considerable attention.

Market Needs and Opportunities on Continental Europe for Pest and Disease Management in Turf

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Pest and disease management in turf in Europe represents a group of small, diverse markets so that the availability of information in this sector is limited. Turf in Europe spans a range of leisure activities, the three main ones being golf courses, sports fields (mainly soccer) and recreational parks. Standards, management techniques and market needs and opportunities vary widely between each activity area. Continental Europe encompasses two distinct climatic zones, the cool temperate north, characterised by the UK, and the warm Mediterranean climate in the south. The most intensively managed turf in both climates is that used for golf: greenkeepers, particularly in the UK, use pesticides and cultural practices to control broad-leaved weeds, grass weeds, diseases and insect pests. Grass weeds and insect pests present more of a threat to turf quality in the warmer southern countries, where *Cynodon* spp. and *Dactylon* spp. are sown rather than *Agrostis* spp. or fine-leaved Fescues.

Sports fields, apart from the small number of international standard venues, consist primarily of ryegrass in both climates. Although 30–35 weed spies can infest playing fields, clover (*Trifolium repens* L.) is viewed as the major weed and there are many cost-effective products available which give reliable control of this problem. Grass weeds, diseases and insect pests are more readily tolerated in the sports turf market.

Recreational areas across the continent have experienced the largest impact of public awareness of pesticide use in the amenity market. Intense pressure to use chemical controls as a last resort, and only if absolutely necessary, have combined with an acceptance of 'weedy' grass in parks as being normal to reduce the potential opportunities. Over the last ten years this trend has even extended into the golf market, where it is now desirable to sow grass and broad-leaved mixtures in the areas of 'rough'.

Overview of the Turf Weed Control Market in the USA

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The US turf market comprises 10M ha of which 7·5M

ha are 'high maintenance' and 2·5M ha 'low maintenance'. High-maintenance turf receives applications of fertiliser, requires regular mowing and occasionally receives applications of pesticide. The primary market segments constituting high-maintenance turf, in terms of M acres, are as follows: residential lawns (5·3), commercial turf (9), golf courses (1·2), schools and colleges (1·8), cemeteries (0·5), turf sod farms (0·3) and municipal parks (1.3).

Three turf climates are recognised in the US, cool- and warm-season turfs and those from a transition zone encompassing the area between the States of Virginia and the Carolinas on the east and Missouri and Arkansas on the west. Cool-season turfs comprise annual and perennial ryegrasses (*Lolium* spp.); red, tall, creeping dwarf and semi-dwarf fescues (*Festuca* spp.); Creeping bentgrass (*Agrostis stolonifera* L.); Kentucky Bluegrass (*Poa pratensis* L.) and Annual Bluegrass (*Poa annua* L.) which is also considered to be a weed. Typical warm-season turf species are hybrid and common Bermudagrass (*Cynodon* spp.), Centipedegrass (*Eremochloa ophiuroides* Hack), St Augustinegrass (*Stenotaphrum secundatum* Kuntze), Kikuyugrass (*Pennisetum clandestinum* Hochst.) and Zoysiagrass (*Zoysia* spp.). In the transition zone, both cool- and warm-season grasses are present, the predominant species being Bermudagrass, Zoysiagrass, fescues, bluegrasses and ryegrasses.

Herbicide costs for weed control in highly maintained turf exceeded US$M200 in 1994 compared with $M1255 in soybeans, $M1375 in maize, $M235 in wheat and $M206 in cotton. Expenditures are increasing by 2–4% per annum, depending on the turf segment concerned. Lawn care operators (LCOs) account for $M206, followed by golf courses ($M35), parks ($M25), landscape contractors ($M20) and educational facilities ($M15). Turf farms, cemeteries and others account for the balance.

Primary products for weed control include pendimethalin, 2,4-D combinations, glyphosate, simazine, benfluralin, diuron, trifluralin, prodiamine and dicamba. Product use varies by segment with the more cost-effective products being used extensively by LCOs and the more specialised products being applied to golf courses. Post-emergent acre-size treatments (primarily for dicotyledonous weeds and sedges) represent over 65% of all treatments.

Herbicide selectivity and turf safety are increasingly important as turf management becomes more sophisticated. The distinctive trend towards more uniform turf requires greater selectivity in herbicide activity. Presently unmet needs include the ability to control Bermudagrass safely in cool-season type turf in the transition zone and to remove *P. annua* safely from bentgrass greens; also the removal of common Bermudagrass from the improved varieties. Plant growth regulators (PGRs) are being used increasingly to aid turf management, the most common ones used on fine turf being trinexapac-ethyl (Ciba), paclobutrazol (O. M. Scotts) and flurprimadol (DowElanco). Lacking 'safe' herbicides, turf managers are exploiting the varying selectivity of the various PGRs to achieve the desired monocultures in turf.